

What is claimed is:

1 1. A memory management apparatus for accessing a physical page  
2 mapped according to mapping information to a logical page that  
3 includes a logical address specified by an access request, the  
4 mapping information showing a one-to-one mapping between a  
5 plurality of logical pages and a plurality of physical pages,  
6 the logical pages being defined by dividing a logical address  
7 space by a predetermined size, each of the physical pages  
8 functioning to physically retain data of the predetermined size  
9 and degrading in storage performance each time an access is made  
10 thereto, the apparatus comprising:  
11 an access frequency index storage unit operable to store  
12 an access frequency index for each logical page, the access  
13 frequency index indicating an occurrence frequency of an access  
14 request specifying a logical address included in a corresponding  
15 logical page;  
16 a degradation index storage unit operable to store a  
17 degradation index for each physical page, the degradation index  
18 indicating a degree of degradation in storage performance of  
19 a corresponding physical page; and  
20 a degradation leveling unit operable to (i) exchange  
21 retained data between a first physical page and a second physical  
22 page, the first physical page being mapped according to the  
23 mapping information to a specific logical page of which an access  
24 frequency index is greater than or equal to a first threshold,  
25 and the second physical page having a degradation index that

26 is less than or equal to a second threshold, and (ii) update  
27 the mapping information so as to show that the specific logical  
28 page is mapped to the second physical page.

1 2. The memory management apparatus according to Claim 1, further  
2 comprising:

3 a cache storage unit operable to store, for each of up  
4 to a predetermined number of the physical pages, cache data that  
5 is a copy of data retained in a corresponding physical page and  
6 that is accessed instead of the original data, and to write,  
7 if cache data has been modified as a result of a subsequent access,  
8 the modified cache data back to a corresponding physical page;  
9 and

10 a degradation index updating unit operable to add a first  
11 value to a degradation index of each physical page that retains  
12 original data of cache data stored in the cache storage unit,  
13 and add a second value to a degradation index of each physical  
14 page to which modified cache data has been written back.

1 3. The memory management apparatus according to Claim 2, wherein  
2 the degradation index updating unit adds, at a time when  
3 cache data is invalidated or replaced by data retained in another  
4 physical page, a sum of the first value and the second value  
5 to a degradation index of a physical page storing original data  
6 of the cache data if the cache data has been modified, and adds  
7 the first value to the degradation index if the cache data has  
8 not been modified.

1 4. The memory management apparatus according to Claim 2, further  
2 comprising  
3 an access frequency index updating unit operable to add  
4 the first value to an access frequency index of a logical page  
5 that is mapped according to the mapping information to each  
6 physical page retaining original data of cache data stored in  
7 the cache storage unit, and to add the second value to an access  
8 frequency index of a logical page that is mapped according to  
9 the mapping information to each physical page to which modified  
10 cache data has been written back.

1 5. The memory management apparatus according to Claim 4, wherein  
2 the access frequency index updating unit adds, at a time  
3 when cache data is invalidated or replaced by data retained in  
4 another physical page, a sum of the first value and the second  
5 value to an access frequency index of a logical page that is  
6 mapped according to the mapping information to a physical page  
7 retaining original data of the cache data if the cache data has  
8 been modified, and adds the first value to the access frequency  
9 index if the cache data has not been modified.

1 6. The memory management apparatus according to Claim 2, wherein  
2 the cache data storage unit further stores, at a time of  
3 storing cache data, a cache access frequency index for the cache  
4 data, an initial value of the cache access frequency index being  
5 set to "0",  
6 the memory management apparatus further comprising:

7           a cache access frequency index updating unit operable to  
8   increment a cache access frequency index of cache data in response  
9   to an access to the cache data; and  
10          an access frequency index updating unit operable to compare,  
11   for each piece of cache data, (i) an access frequency index of  
12   a logical page that is mapped according to the mapping information  
13   to a physical page retaining original data of a corresponding  
14   piece of cache data and (ii) a cache access frequency index of  
15   the corresponding piece of cache data, and to update the access  
16   frequency index with the cache access frequency index if the  
17   cache access frequency index is greater than the access frequency  
18   index.

1   7. The memory management apparatus according to Claim 6, wherein  
2          the access frequency index updating unit performs the  
3   update at predetermined time intervals and resets all the cache  
4   access frequency indexes to "0".

1   8. The memory management apparatus according to Claim 6, wherein  
2          the access frequency index updating unit calculates, for  
3   each piece of cache data, a normalized cache access frequency  
4   index by normalizing a cache access frequency index based on  
5   a time period during which a corresponding piece of cache data  
6   is retained in the cache storage unit, compares the normalized  
7   cache access frequency index and an access frequency index of  
8   a logical page mapped according to the mapping information to  
9   a physical page storing original data of the corresponding piece

10 of cache data, and updates the access frequency index with the  
11 normalized cache access frequency index if the normalized cache  
12 access frequency index is greater than the access frequency  
13 index.

1 9. The memory management apparatus according to Claim 1, wherein  
2 each logical page has a generic logical address that is  
3 included in a corresponding logical page,  
4 the memory management apparatus further comprising:  
5 a detecting unit operable to detect an access request  
6 specifying any of the generic logical addresses;  
7 a degradation index updating unit operable to increment  
8 a degradation index of a physical page mapped according to the  
9 mapping information to a logical page that includes a generic  
10 logical address specified by an access request detected by the  
11 detecting unit; and  
12 an access frequency index updating unit operable to  
13 increment an access frequency index of the logical page that  
14 includes the generic logical address specified by the detected  
15 access request.

1 10. The memory management apparatus according to Claim 9, wherein  
2 each generic logical address is a logical address that  
3 is accessed whenever a logical page including a corresponding  
4 generic logical address is accessed.

1 11. The memory management apparatus according to Claim 1, wherein

2           each physical page is implemented by a ferroelectric random  
3   access memory.

1   12. A memory management apparatus for accessing a physical page  
2   mapped according to mapping information to a logical page that  
3   includes a logical address specified by an access request, the  
4   mapping information showing a one-to-one mapping between a  
5   plurality of logical pages and a plurality of physical pages,  
6   the logical pages being defined by dividing a logical address  
7   space by a predetermined size, each of the physical pages  
8   functioning to physically retain data of the predetermined size  
9   and degrading in storage performance each time an access is made  
10   thereto, the apparatus comprising:

11           an access frequency index storage unit operable to store  
12   an access frequency index for each logical page, the access  
13   frequency index indicating an occurrence frequency of an access  
14   request specifying a logical address included in a corresponding  
15   logical page;

16           a cache storage unit operable to store cache data for each  
17   of up to a predetermined number of the physical pages in  
18   association with a replication access frequency index that is  
19   a copy of an access frequency index of a logical page mapped  
20   according to the mapping information to a corresponding physical  
21   page, the cache data being a copy of data retained in the  
22   corresponding physical page and that is accessed instead of the  
23   original data; and

24           a degradation leveling unit operable, when one of the

25 pieces of cache data needs to be replaced with data retained  
26 in a new physical page, to replace cache data associated with  
27 a replication access frequency index that is less than or equal  
28 to an access frequency index of a logical page mapped according  
29 to the mapping information to the new physical page.

1 13. The memory management apparatus according to Claim 12,  
2 further comprising  
3 a replication access frequency index updating unit  
4 operable, in response to an access to cache data, to decrement  
5 a replication access frequency index associated with the cache  
6 data.

1 14. The memory management apparatus according to Claim 12,  
2 wherein  
3 each physical page is implemented by a ferroelectric random  
4 access memory.

1 15. A memory management method for accessing a physical page  
2 mapped according to mapping information to a logical page that  
3 includes a logical address specified by an access request, the  
4 mapping information showing a one-to-one mapping between a  
5 plurality of logical pages and a plurality of physical pages,  
6 the logical pages being defined by dividing a logical address  
7 space by a predetermined size, each of the physical pages  
8 functioning to physically retain data of the predetermined size  
9 and degrading in storage performance each time an access is made

10 thereto, wherein  
11 the method employs (i) an access frequency index indicating,  
12 for each logical page, an occurrence frequency of an access  
13 request specifying a logical address included in a corresponding  
14 logical page and (ii) a degradation index indicating, for each  
15 physical page, a degree of degradation in storage performance  
16 of a corresponding physical page,  
17 the method comprising:  
18 a degradation leveling step of (i) exchanging retained  
19 data between a first physical page and a second physical page,  
20 the first physical page being mapped according to the mapping  
21 information to a specific logical page of which an access  
22 frequency index is greater than or equal to a first threshold,  
23 and the second physical page having a degradation index that  
24 is less than or equal to a second threshold, and (ii) updating  
25 the mapping information so as to show that the specific logical  
26 page is mapped to the second physical page.

1 16. The memory management method according to Claim 15, further  
2 comprising:  
3 a cache managing step of storing, for each of up to a  
4 predetermined number of the physical pages, cache data that is  
5 a copy of data retained in a corresponding physical page and  
6 that is accessed instead of the original data, and of writing,  
7 if cache data has been modified as a result of a subsequent access,  
8 the modified cache data back to a corresponding physical page;  
9 and

10           a degradation index updating step of adding a first value  
11   to a degradation index of each physical page that retains original  
12   data of cache data stored in the cache storage step, and adding  
13   a second value to a degradation index of each physical page to  
14   which modified cache data has been written back.

1   17. The memory management method according to Claim 15, wherein  
2       each logical page has a generic logical address that is  
3   included in a corresponding logical page,  
4       the memory management method further comprising:  
5       a detecting step of detecting an access request specifying  
6   any of the generic logical addresses;  
7       a degradation index updating step of incrementing a  
8   degradation index of a physical page mapped according to the  
9   mapping information to a logical page that includes a generic  
10   logical address specified by an access request detected in the  
11   detecting step; and  
12       an access frequency index updating step of incrementing  
13   an access frequency index of the logical page that includes the  
14   generic logical address specified by the detected access request.

1   18. A memory management method for accessing a physical page  
2   mapped according to mapping information to a logical page that  
3   includes a logical address specified by an access request, the  
4   mapping information showing a one-to-one mapping between a  
5   plurality of logical pages and a plurality of physical pages,  
6   the logical pages being defined by dividing a logical address

7 space by a predetermined size, each of the physical pages  
8 functioning to physically retain data of the predetermined size  
9 and degrading in storage performance each time an access is made  
10 thereto, wherein

11 the method employs (i) an access frequency index indicating,  
12 for each logical page, an occurrence frequency of an access  
13 request specifying a logical address included in a corresponding  
14 logical page and (ii) a degradation index indicating, for each  
15 physical page, a degree of degradation in storage performance  
16 of a corresponding physical page,

17 the method comprising:

18 a cache storing step of storing cache data for each of  
19 up to a predetermined number of the physical pages in association  
20 with a replication access frequency index that is a copy of an  
21 access frequency index of a logical page mapped according to  
22 the mapping information to a corresponding physical page, the  
23 cache data being a copy of data retained in the corresponding  
24 physical page and that is accessed instead of the original data;  
25 and

26 a degradation leveling step of, when one of the pieces  
27 of cache data needs to be replaced with data retained in a new  
28 physical page, replacing cache data associated with a replication  
29 access frequency index that is less than or equal to an access  
30 frequency index of a logical page mapped according to the mapping  
31 information to the new physical page.